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RI LEFSCHETZ CENTER FOR DYNAMICAL SYSTEMS J K HALE
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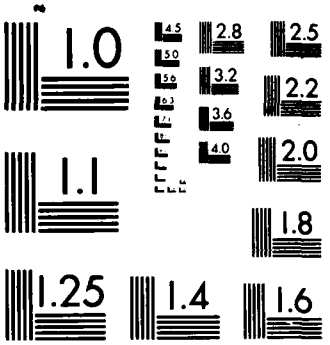

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This research involves extensive studying of the problem of transverse homoclinic orbits of periodic orbits of functional differential equations (FDE's), and also systems of reaction diffusion equations and attempting to understand the effects of boundary conditions on the flow when the diffusion coefficients and the boundary conditions are varied.

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AFOSR SCIENTIFIC PROGRESS REPORT FOR YEAR 1984-85

Grant # AFOSR 84-0376

Jack K. Hale

The thrust of the research fell into two categories.

1. **Chaos in delay equations.**

Hale and Lin have studied extensively the problem of transverse homoclinic orbits of periodic orbits of functional differential equations (FDE's). They have shown that the classical symbolic dynamics for such problems in finite dimension also holds for FDE's (Hale and Lin [1]). These results were applied to two examples that had previously been considered by Walther and an der Heiden (Hale and Lin [2]). For these examples, it was shown that there was a transverse homoclinic orbit to a periodic orbit and, thus, "chaos" occurs and is persistent under perturbations of the vector field. The latter important property could be obtained by the methods of Walther and an der Heiden.

If there is a homoclinic orbit to a periodic orbit for an FDE, it is important to know if there is a small perturbation of the vector field which will lead to a transverse homoclinic orbit. This was shown to be true by Hale and Lin [3]. The methods are new even for the finite dimensional case.

Work is continuing on these problems, combining theory and numerical computations.

2. **Varying diffusivity and boundary conditions in reaction-diffusion equations.**

Hale and Rocha have been studying extensively systems of reaction diffusion equations and attempting to understand the effects of boundary conditions on the flow when the diffusion coefficients and the boundary conditions are varied. Hale [4] has extended the results of Conway, Hoff and Smoller on large diffusivity and Neumann conditions to allow situations where invariant regions do not exist. For

large diffusivity, Hale and Rocha [5] have studied the effects of variations in the boundary conditions on the flow on the attractor. These results clarify the concept of well-mixed when the boundary conditions are not of Neumann type. Hale and Rocha are continuing work in this direction and now are completing a manuscript showing how the flow changes as one goes from Neumann to Dirichlet conditions.

References

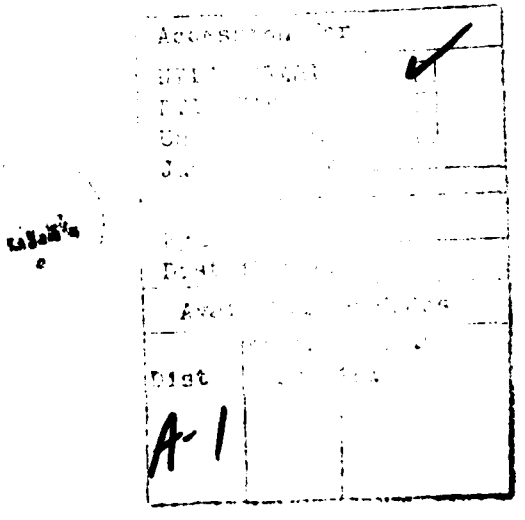
[1] J. K. Hale and X.-B. Lin, "Symbolic dynamics and nonlinear semiflows," LCDS Report #84-8, Brown University, May 1984.

[2] J. K. Hale and X.-B. Lin, "Examples of transverse homoclinic orbits in delay equations," LCDS Report #84-30, Brown University, September 1984, J. Nonlinear Analysis, submitted.

[3] J. K. Hale and X.-B. Lin, "Heteroclinic orbits for retarded functional differential equations," LCDS Report #84-39, Brown University, December 1984, J. Differential Equations, to appear.

[4] J. K. Hale, "Large diffusivity and asymptotic behavior in parabolic systems," LCDS Report #85-1, Brown University, January 1985, J. Math. Analysis and Appl., to appear.

[5] J. K. Hale and C. Rocha, "Varying boundary conditions with large diffusivity," LCDS Report #85-5, March 1985.



SYMBOLIC DYNAMICS AND NONLINEAR SEMIFLOWS

J. K. Hale and X.-B. Lin

ABSTRACT

For a transverse homoclinic orbit γ of a mapping (not necessarily invertible) on a Banach space, it is shown that the mapping restricted to orbits near γ is equivalent to the shift automorphism on doubly infinite sequences on finitely many symbols. Implications of this result for the Poincaré map of semiflows are given.

EXAMPLES OF TRANSVERSE HOMOCLINIC ORBITS IN DELAY EQUATIONS

by

Jack K. Hale and Xiao-Biao Lin

ABSTRACT

Examples are presented of differential difference equations $\dot{x}(t) = -\alpha x(t) + f(x(t-1))$, $\alpha \geq 0$, f close to a step function, for which there is a periodic orbit with a transverse homoclinic orbit.

HETEROCLINIC ORBITS FOR RETARDED FUNCTIONAL DIFFERENTIAL EQUATIONS

by J. K. Hale and X.-B. Lin

ABSTRACT

Suppose Γ is a heteroclinic orbit of a C^k functional differential equation $\dot{x}(t) = f(x_t)$ with α-limit set $\alpha(\Gamma)$ and ω-limit set $\omega(\Gamma)$ being either hyperbolic equilibrium points or periodic orbits. Necessary and sufficient conditions are given for the existence of an $\tilde{f}$ close to f in C^k with the property that $\dot{x}(t) = \tilde{f}(x_t)$ has a heteroclinic orbit $\tilde{\Gamma}$ close to Γ. The orbits $\tilde{\Gamma}$ are obtained from the zeros of a finite number of bifurcation functions $G(\beta,\tilde{f}) \in \mathbb{R}^{d^*}$, $\beta \in \mathbb{R}^{d+1}$. Transversality of Γ is characterized by the nondegeneracy of the derivative $D_\beta G$. It is also shown that the $\tilde{f}$ which have heteroclinic orbits near Γ are on a C^k submanifold of finite codimension = $\max\{0, -\text{ind}\,\Gamma\}$ or on the closure of it where $\text{ind}\,\Gamma$ is the index of Γ.

Large Diffusivity and Asymptotic Behavior in Parabolic Systems

by

Jack K. Hale

Abstract

For systems of reaction-diffusion equations with Neumann boundary conditions, it is shown that the solutions are asymptotic to the solutions of an ordinary differential equation if the diffusivity is large. The methods apply also to reaction-diffusion systems with time delays.

VARYING BOUNDARY CONDITIONS
WITH LARGE DIFFUSIVITY

by

Jack K. Hale and Carlos Rocha

ABSTRACT

For systems of semilinear parabolic partial differential equations on bounded domains with large diffusivity and homogeneous boundary conditions close to the Neumann conditions, we associate a system of ordinary differential equations (ode's) from which the dynamics of the original system can be inferred. Small perturbations of the Neumann case produce large perturbations in the ode's with corresponding effects on the dynamics of the system. The same theory is valid for functional differential equations. Applications are considered in models for control by genetic repression of biological material in cells.

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